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Original Research Article

Cochlear implant: factors that impact hearing outcomes

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ABSTRACT

Background: Cochlear implant has been providing hearing rehabilitation to patients with severe hearing loss. However, not all patients achieve optimal results, and the goal of this study was to evaluate the factors that influence hearing outcomes in cochlear implantation.
Methods: This was a retrospective analysis of the patients who underwent cochlear implantation in our institution between 2018 and 2021. Review of clinical files and complementary tests, and analysis of hearing outcomes and complications were performed.
Results: Sixty-nine cochlear implants were placed in 64 patients, with an average age of 49.3 years. In initial evaluation post activation and 1 year after implantation, the average pure tone average (PTA) was 37 dB, with a vocal discrimination of 48.7% at 50 dB, and 28, 6 dB, with a discrimination of 73.8% at 50 dB, respectively. Patients with postlingual deafness had better hearing outcomes at 1 year post surgery, in both PTA (27.9 compared to 33 dB) and discrimination at 50 dB (76.5 compared to 56.1%). Only one case had a major complication.
Conclusions: In conclusion, we found that increased implant use by the patient, postlingual deafness, and in-creased surgeon experience, were factors that improved hearing outcomes in patients undergoing cochlear implantation.

Keywords: Sensorineural hearing loss, Cochlear implant, Complications, Hearing outcomes

INTRODUCTION

Unilateral or bilateral cochlear implantation is a surgical procedure that has provided auditory rehabilitation in patients with severe to profound hypoacusis without functional gain with hearing aids, with a positive impact on the patients' quality of life.[1-3]

The cochlear implant consists of an external processor that detects the sound stimulus from the environment and converts it into an electrical signal, transmitting it to the second component, a receiver/stimulator that is implanted and directly stimulates the cochlear nerve, bypassing the normal auditory mechanism.[2,4] The evaluation of candidates for cochlear implantation is thorough and involves a multidisciplinary team including an otorhinolaryngologist, audiologist and speech therapist.[2]

Our institution's preoperative protocol for cochlear implant candidates includes a tonal and vocal audiometric study of the patient's hearing and the gain with conventional hearing aids, brainstem auditory evoked potentials, vestibular evaluation using videonystagmography or video-head impulse test, imaging study with computed tomography (CT) of the ears and magnetic resonance imaging (MRI), to obtain information about the surgical anatomy and possible difficulties that may arise during the procedure, and to confirm the integrity of the cochlear nerves and inner ear.[5] It is a well-defined and safe procedure, with a complication rate

currently around 15-20%.[1,6] Potential complications may be classified as minor, if they can be resolved with conservative treatment or simple procedures, or major, in case they require surgical re-vision or hospitalization for medical treatment.[1]

The objective of this study was to study the characteristics of the population who underwent cochlear implantation in our institution, and analyze the factors that influenced the hearing out-comes.

METHODS

This study is a retrospective analysis of patients who underwent cochlear implant placement at the otorhinolaryngology department at Centro Hospitalar Universitário de Santo António, in Portugal, between January 2018 and December 2021.

Sociodemographic data were collected through the patients' clinical file: sex, age, etiology and duration of hearing loss, previous rehabilitation with hearing aids; and data related to the surgical procedure through the details of the surgical report. The results of complementary diagnostic tests were analyzed: pre- and post-operative audiometric study, ear CT, MRI, and pre-operative vestibular evaluation.

All surgeries were performed by the same surgeon. The surgical approach was always performed in the same way, using the facial recess approach, performing a mastoidectomy with posterior tympanotomy, and introducing the electrode through the round window after incising its membrane whenever possible. In cases where round window access was hampered by anatomic variations, a cochleostomy was performed on the promontory anterior to the round window to introduce the electrode.

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS™) version 26. Categorical variables were analyzes using the Chi-square test. Continuous variables were analyzed using the Mann-Whitney test if two categories, or the Kruskal-Wallis test if more than two categories. Paired variables were tested with the Wilcoxon test.

The correlation between two continuous variables was analyzed using Pearson's correlation test.

RESULTS

Relating to population

Table 1 shows the sociodemographic data of the patients.

The vast majority of procedures were performed in adults, and only in 4 patients of pediatric age. All children were implanted bilaterally, 3 of them at the same surgical time, and all adults (n=60) underwent unilateral cochlear implantation.

As for the etiology of deafness, 5 (7.8%) were post-meningitis, 3 (4.7%) post trauma, 3 (4.7%) otosclerosis, and 1 (1.6%) due to the use of ototoxic drugs. 7 (10.9%) were cases of pre-lingual deafness of unknown cause, and 45 (70.3%) post-lingual deafness of unknown cause.

Relating to surgical procedure

Table 2 represents information regarding the cochlear implantation procedure. Anatomical findings were reported in 13 surgeries (18.8%), but their presence did not correlate with an increase in surgery duration (p=0.121). All surgeries were performed by the same surgeon.

Figure 1 shows the evolution in surgical time with increasing experience in this procedure. Surgical time correlated negatively with increasing surgeon experience (Pearson's correlation of -0.584 (p=0.01)).

The cochlear implants placed were from 3 different companies: Advanced Bionics™ (36/69), MedEl™ (16/69), and Cochlear™ (17/69).

Relative to pre-operative assessment

Within the subgroup submitted to unilateral cochlear implant (n=60), 52.3% had symmetrical hearing loss and vestibular evaluation without alterations. In the remaining 47.7%, it was verified that the decision of the ear to be implanted was based on the ear with worse hearing in 27.7%, on the ear with worse vestibular function in 13.8%, and on unilateral anatomical alterations that could condition the results in 5.6% of cases (one case of cochlear ossification, 3 of cochlear nerve hypoplasia).

Relative to complications

Regarding major complications, there was only one case (1.5%), requiring surgical revision due to implant failure. After placing the new implant, this patient had good hearing results. As for minor complications, they occurred in a total of 20% of the cases. 4 cases required sacrifice of the chorda tympani for surgical access, 8 cases had complaints of postoperative vertigo, and only 1 of these led to prolonged hospital stay, and 2 cases of inflammation in the area of the implant, which yielded to topical antibiotics.

Relative to hearing outcomes

Regarding overall hearing outcomes, in the initial postoperative evaluation after activation, the average pure tone average (PTA) was 37 dB, with discrimination of 48.7% to 50 dB, and after follow-up consultations, audio-verbal therapy sessions, average PTA of 28.6 dB, with discrimination of 73.8% at 50 dB. This improvement in auditory thresholds was statistically significant (p<0.001).

While no significant difference was found in outcomes in the first month after activation, patients with postlingual deafness had better hearing outcomes than patients with prelingual deafness at 1 year post surgery, in both PTA and discrimination (Table 3). Comparing etiology of deafness, no difference was found in hearing outcomes. Previous amplification with conventional hearing aids, duration of deafness without rehabilitation, or patient age, did not impact hearing outcome in this study.

Concerning factors involving the surgical procedure, surgeon experience had an impact on 1 month (p=0.04) and 1 year PTA (p=0.04), when divided by year of surgery. These values improved from a mean and standard deviation of 41.7 (9.7) to 32.8 (11.1) dB, and 31.9 (4.2) to 25.2 (7.2) dB, respectively. However, this improvement was not verified when comparing vocal discrimination. Neither a "difficult surgery" (defined by the presence of one of the anatomic findings stated in Table 2), surgery duration, nor the occurrence of minor complications had an impact on the auditory outcome.

Table 1: Patient socio-demographic data.

Socio-demographic data	N (%)
Sex	
Female	40 (62.5)
Male	24 (37.5)
Age, mean in years (SD)	49.3 (17.4)
Deafness etiology, n (%)	
Meningitis	5 (7.8)
Trauma	3 (4.7)
Otosclerosis	3 (4.7)
Ototoxic medication	1 (1.6)
Unknown	52 (81.2)
Hearing loss duration, mean in years (SD)	28.4 (18.5)
Previous rehabilitation with hearing aids n (%)	
Yes	34 (53.1)
No	30 (40.6)

Table 2: Data regarding surgical procedure.

Surgical data	N (%)
Operated ear	
Left	39 (56.6)
Right	30 (43.5)
Surgical approach	
Round window	66 (95.7)
Tympanic cochleostomy	2 (2.9)
Vestibular cochleostomy	1 (1.4)
Anatomic findings	
Prominent lateral sinus	1 (1.4)
Low tegmen tympani	1 (1.4)
Deep oval window niche	8 (11.6)
Round window membrane fibrosis	1 (1.4)
Perilymph fistula	1 (1.4)
Sclerotic mastoid	1 (1.4)
Surgical time, mean in minutes (SD)	222 (97.3)

Table 3: Hearing outcomes divided by pre/post lingual hearing loss.

Parameter, mean (SD)	Pre-lingual	Post-lingual	P*
PTA at 1 month	39.1 (9.6)	36.8 (13)	0.496
Vocal discrimination at 50 dB at 1 month	33.8 (33)	50.4 (35.1)	0.22
PTA at 1 year	33 (5.5)	27.9 (7.5)	0.03
Vocal discrimination at 50 dB at 1 year	56.1 (29.8)	76.5 (26.7)	0.04

Note:*- Statistically significant at p<0.05.

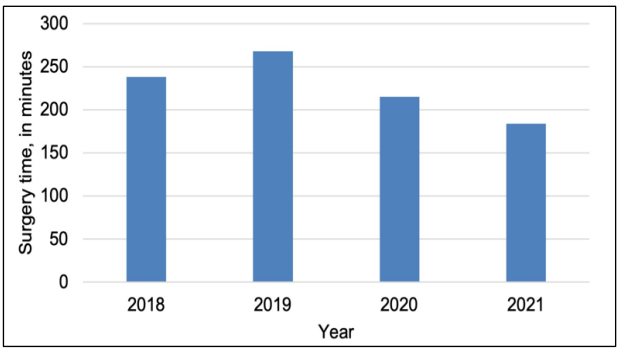

Figure 1: Mean surgery duration in minutes, divided per year.

DISCUSSION

Unilateral cochlear implants improve vocal discrimination and quality of life in patients with severe to profound deafness. The bilateral implant adds the additional benefit of improved sound localization.[7]

The approach used to introduce the electrode into the scala tympani at our institution is through the round window, as per the surgeon's preference. However, cases in which access was more complicated or even requiring a cochleostomy approach did not show worse hearing results.

One case required insertion of the electrode in the scala vestibuli, intentionally performed due to ossification of the scala tympani. Insertions in the scala vestibuli are a viable alternative in cases of malformation, absence or obstruction of the scala tympani, since they do not traumatize neuronal or bone structures. However, this approach can cause rupture of Reissner's membrane and destroy residual hearing, so it should be avoided in patients who have some preserved cochlear function.[8]

This procedure is performed in centers around the world, and it is important to evaluate its efficacy and safety to maximize hearing results and minimize the incidence of complications.[6] Complications of this procedure may be related to the surgical technique used, foreign body reaction, or failure of the implanted device. The most used

classification divides them into minor complications, which are resolved with conservative or minimally invasive treatment, or major, if they imply surgical review or hospitalization for medical treatment.[1] In our study, only one case required surgical revision and re-implantation (1.4%), due to implant failure, which tends to be the most common cause for revision in other studies. Overall, our complication rate was 20%, similar to what is de-scribed in the literature.[1,6]

Several factors can influence hearing results, such as duration of deafness, age at the time of implantation, etiology of deafness, previous use of hearing aids, and greater experience with cochlear implants.[9] In this study, there was a statistically significant improvement in the hearing outcomes with increased patient experience with the cochlear implant, both in PTA and vocal discrimination at 50 dB. Furthermore, patients with postlingual deafness had better hearing outcomes than prelingual at 1 year post im-plantation. Increasing surgeon experience had a positive impact on PTA, but no correlation with vocal discrimination.

In this study we did not find correlation of hearing outcomes with patient age, previous use of hearing aids, duration of deafness, or etiology. This may be due to some of the study's limitations, such as it being a retrospective analysis, and with a small sample size.

Heterogeneous results with cochlear implants in patients with cochlear nerve hypoplasia or aplasia have been described, but patients with hypoplastic nerves and no syndromic condition may have better cochlear implant performance with good vocal discrimination.[10] This study did not find differences in the auditory results of these patients compared to those who did not present alterations in terms of the cochlear nerves in the MRI, but it was a small sample of only 3 patients.

CONCLUSION

In recent years, our institution has been responding to cases of severe to profound deafness with an indication for the placement of a cochlear implant. Auditory results have been positive, with a low rate of complications. In this study, we found that increased implant use by the patient, post-lingual deafness, and increased surgeon experience, were factors that improved hearing outcomes in patients undergoing cochlear implantation.

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